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# Inverse Ultravelocity Slings for Boost-Phase Defense

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# *Inverse Ultravelocity Slings for Boost-Phase Defense*

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# INVERSE ULTRAVELOCITY SLINGS FOR BOOST-PHASE DEFENSE

by

Gregory H. Canavan

ABSTRACT

Existing booster technology, brilliant pebble interceptors, survivable platforms, and developed warning, command, control, and communication could provide boost-phase defensives with the capability and flexibility required to significantly reduce the effectiveness of submarine and theater attacks.

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## I. INTRODUCTION

The paper that introduced "brilliant pebbles" as boost-phase defenses also discussed their use as ultravelocity slings. The slings would use conventional boosters to accelerate very small payloads to high enough velocities to reach intercontinental ballistic missiles (ICBMs) in their boost phase from launchers in the US.[1]

For ICBMs, slings' performance would degrade in time if the ICBM boost and deployment times were reduced, because the velocities required would be prohibitive. For SLBMs that need not be the case. From the shore or from ships in the same bodies of water in which SSBNs were deployed, slings would have shorter ranges and could remain viable.

The same is true of theater defenses, where forward basing would overcome Earth curvature and allow a single site to cover all of Europe and much of Asia. That would overcome the large,

redundant inventories that are thought to penalize ground-based theater missile defenses.[2]

II. ANALYSIS

A useful point of reference is the exoatmospheric intercept system (ERIS) interceptor, which uses a booster weighing $M_B \approx$ a few tons to accelerate a $M_E \approx 300$ kg kill package to $V_E \approx 5$ km/s.[3] A booster of roughly that size should be able to accelerate a $M_B \approx 30$ kg brilliant pebble to $V_E \approx V_E + c \cdot \ln(M_E/M_B) \approx 5$ km/s $+ 2.5 \cdot 5.8 \approx 19.5$.

Brilliant pebbles have an additional velocity increment of $\approx$ 6 km/s, so their kill packages could be accelerated to 20-25 km/s, 6-7 times the SLBM's average boost-phase velocity. With that velocity a sling could reach SLBMs by their booster burnout at $T \approx 300$ s from a distance of $\approx$ 6,000 km away. No patrol areas have radii that large; ideally a single ship could cover an entire basin. There could, however, be delays in initiating and executing the intercept.

For booster of average acceleration a, the time to reach V is V/a, which reduces the sling's range by $V^2/2a$. For V = 20 km/s and a = 20 g, the acceleration time is $\approx$ 100 s, and the range reduction is about 1,000 km, which are significant, but tolerable. For lower velocities the penalties would be less. The time to detect launch and establish track with current sensors could be comparable to the acceleration time, but for many, low altitude sensors with overlapping coverage, e.g. brilliant pebble eyes, the time could be much shorter.

The longest delay could be that for the decision to release the sling. For phase 1 space based boost-phase interceptors that delay is estimated to be a few minutes; it could be reduced for later phases.[4,5,6]

Taking these delays into account, the slings' range is approximately

$$R = V(T - T_d) - V^2/2a, \qquad (1)$$

where $T_d$ is the delay for release. Figure 1 shows range versus sling velocity for SLBM engagement times of T = 200, 300, and 400

s and a current $T_d$ of 120 s. For 400 s, which is typical of current SLBMs, the range roughly doubles from 2.5 to 5.5 Mm as V increases from 10 to 25 km/s. For 300 s the difference is under a factor of 2. For 200 s the range flattens out, because the fly out time, $T - T_d \approx 80$ s is so short that the sling spends little time at maximum velocity.

The engagement time is made up of the SLBM booster burn and bus deployment times. The former is currently ≈ 300 s; fast burn booster technology is harder to employ for SLBMs, so the burn time could remain at 200-300 s. Bus deployment times are currently ≥ 300 s. For current serial deployments the number of RVs released increases roughly linearly from 0 at T to all of them at $T + T_d$, so on the average the value of a bus phase intercept is only about half. The 400 s engagement time assumes roughly half of the intercepts of current 300 s buses.[7]

In time buses could get faster, but if their boosters could only get down to 150-200 s, even parallel deployment, which involves a significant penalty in the number of RVs carried, would leave the engagement time at 300 s. Thus, Fig. 1 indicates that ranges of 2-5 Mm should be possible with developed sensors and control.

Figure 2 shows the sensitivity to decision times from 0 to 150 s. The velocity plotted is that needed to reach a SLBM at range 2 Mm. The bottom curve is for a current T = 400 s. At $T_d = 0$, i.e. automatic launch, $V \approx 5$ km/s; even for $T_d = 100$ s, $V \approx 7$ km/s, which could be reached with current kill packages. The top curve is for T = 300 s. At $T_d = 0$, $V \approx 7$ km/s; for $T_d = 100$ s, $V \approx 12$ km/s, which is well within the capabilities estimated above. Comparing the two curves suggests that slings should be relatively insensitive to delays of a few minutes.

These comments are predicated on the survival of the sling launch platform. Although they would only have to survive for the first few hundred seconds, they would presumably be attacked before launch if their purpose was known, since they would be in open water. One approach would be to spread the slings over a number of smaller vessels or SSNs, which would reduce the mass

and improve performance. An alternative would be to conceal the slings on nonmilitary flag ships in transit. Their modest masses could make that attractive and noninterfering.

## III. SUMMARY AND CONCLUSIONS

Simple estimates indicate that a combination of existing booster technology, brilliant pebble interceptors, survivable ocean platforms, and developed warning, command, control, and communication could provide boost-phase defensives with the capability and flexibility required to significantly reduce the effectiveness of SSBN launchers. This report adds little technically to the original note; it mainly points out that the current interest in theater defenses could justify further study.

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Fig. 1 Range vs velocity

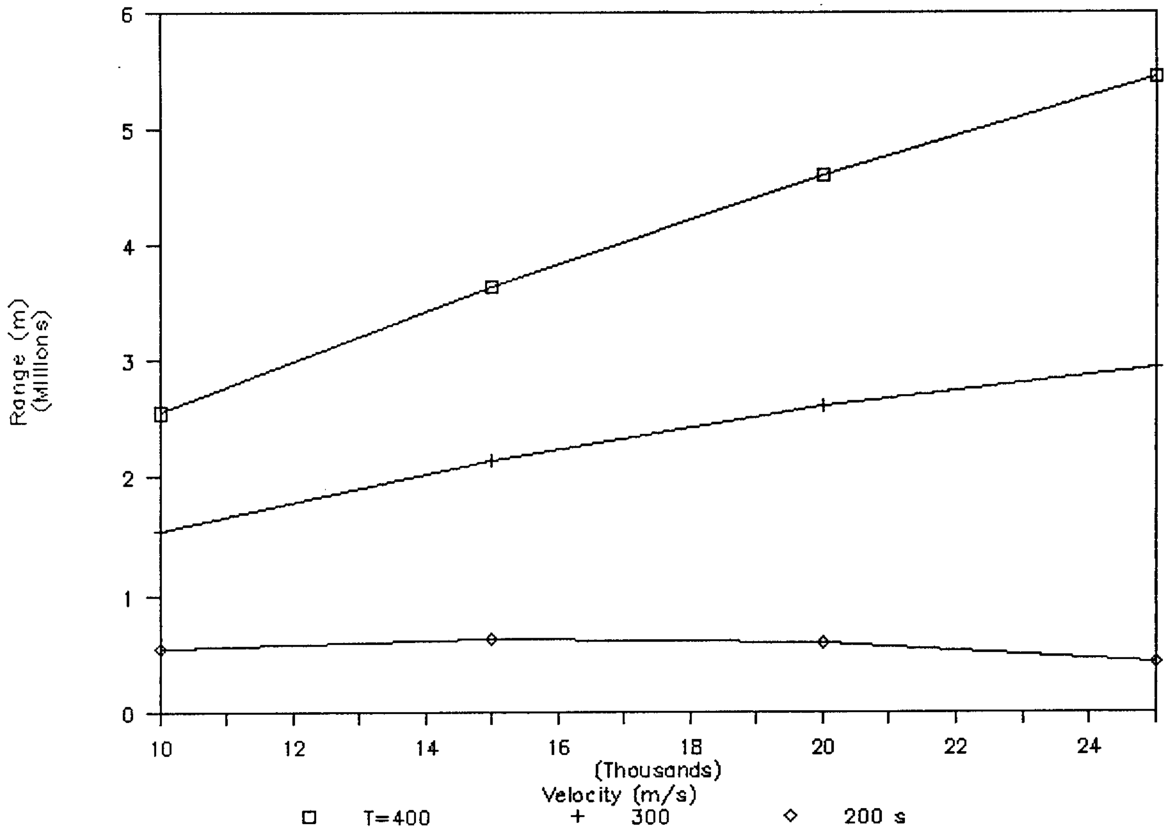


Fig.2 Velocity vs decision time